A PERSPECTIVE ON TRANSBOUNDARY ENVIRONMENTAL ISSUES

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PREFACE

"Transboundary Issues" was prepared by Concord Environmental at the request of the British Columbia Round Table on the Environment and the Economy. It is part of a series of background reports dealing with issues which Round Table considered important to the development of a sustainable development strategy in British Columbia. It is intended to provide information that will assist the dialogue between the Round Table and the public.

The Round Table has not endorsed the report. The information provided and conclusions reached in this document are those of the author.

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EXECUTIVE SUMMARY

Transboundary Issues

This background report focuses on some major environmental issues that have continental and global implications.

The causes and effects of ozone depletion in the stratosphere, global warming, long-range transport of air pollutants, and marine oil spills are discussed at length.

The author includes an assessment of British Columbia's contributions to each of these problems. Local initiatives to solutions are also discussed, and existing government activities identified.

CONTENTS

1 Summary

2 Synopsis of Transboundary Issues

3 Stratospheric Ozone Depletion

4 Global Warming

5 Long-Range Transport of Air Pollutants

6 Marine Pollution - Oil and Chemical Spills

7 Conclusion

8 Bibliography

1 SUMMARY

This discussion paper has been prepared for the British Columbia Round Table on The Environment and The Economy as one of a series of papers intended to guide thinking about the issues facing B.C. while planning for environmentally sustainable economic development. The paper focuses on issues which transcend the boundaries of the province or of a region and attempts to place these in the context of the deliberations of the Round Table's Core Group on Sustainable Development Strategy. This background paper has been written for the general reader and is intended to provide information for the public consultation phase of the Round Table's proceedings.

The paper presents brief summaries of a few important issues which extend beyond the boundaries of municipalities and the Province as examples of the kinds of sustainability issues which B.C. will be called upon to address frequently in the future. The examples which have been chosen are large in scale, but each has mechanisms or institutions already in place to provide a means of cooperative action to prepare B.C. appropriately.

The major issues chosen are

- Stratospheric Ozone Depletion
- Global Warming
- Long-Range Transport of Air Pollutants
- Marine Pollution - Oil and Chemical Spills.

Highlights are provided of a few other issues which might have been addressed in more detail.

Each of these issues requires B.C. to look across municipal, regional or provincial boundaries and to seek mutual strategies and solutions with neighbours. In most cases, strategies are more likely developments for the near future, rather than solutions, for these issues, and many others like them, are not well-defined. Their impacts on B.C. (or Canada, or the world, for that matter) are not well-understood, but the scale and potential magnitude of their effects are so important that they must be addressed in the absence of complete information.

The importance of these issues to B.C. may turn out to be more in the examples which they set for future action on sustainability issues than their own eventual impacts on B.C. Some of them will surely have effects on both B.C.'s environment and B.C.'s economy. A synopsis is presented for each issue, and each is then presented in terms of local contributions to the problem and local contributions to the solution.

Most of these issues require a better knowledge base before their impacts may be known conclusively, for example, regional impacts of global warming or long-range transported acidic deposition. For other issues, there is sufficient knowledge to provide the basis for reasoned action, such as chlorofluorocarbons and their effect on stratospheric ozone depletion, or the risks of marine oil spills or the contribution of vehicle emissions in urban areas to regional ozone formation.

2 SYNOPSIS OF TRANSBOUNDARY ISSUES

Introduction

This discussion paper has been prepared for the British Columbia Round Table on The Environment and The Economy as one of a series of papers intended to guide thinking about the issues facing B.C. while planning for environmentally sustainable economic development. The paper focuses on issues which transcend the boundaries of the province or of a region and attempts to place these in the context of the deliberations of the Round Table's Core Group on Sustainable Development Strategy. This background paper has been written for the informed, general reader and is intended to provide information for the public consultation phase of the Round Table's proceedings. The content is the sole responsibility of the consultant.

Background

The strategy of thinking globally / acting locally has become a fundamental principle of achieving environmentally sustainable economic development. The value of locally-initiated action, that is, of grassroots or bottom-up initiatives, as contributions toward larger-scale solutions, is well established. In the context of sustainable development, it is necessary to identify goals and objectives toward which direct local action may contribute. The purpose of this paper is to identify and describe briefly a few current issues which transcend provincial boundaries, so that the ways in which these issues are being addressed may suggest that there are models for addressing other, similar issues. The issues covered here are those which already command attention from governments and citizens of B.C on a regional, continental or global scale .

Stratospheric Ozone Depletion

Stratospheric ozone depletion is the best current example of the success of the predictions by scientific models of large-scale atmospheric changes due to man's activities. The observation of an "ozone hole" over Antarctica in 1985 (and later over the Arctic) confirmed the predictions which atmospheric modellers first put forward in the mid-1970's and firmly established the credibility of the scientists who predicted the phenomenon.

The stratospheric ozone layer is about 20 km deep and exists at altitudes of 15 to 50 km above the earth's surface. The concentration of ozone in this layer is low - it would comprise a layer only about 3 mm deep if it were brought to normal atmospheric pressure at ground level. Ozone at this altitude is produced by the action of the sun's ultraviolet light rays on oxygen molecules in the atmosphere. The ozone molecules so produced in turn absorb ultraviolet light from the sun. This process shields the surface of the earth from the range of ultraviolet rays known as UV-B, whose intensity at ground level is weakened because of this process. In short, stratospheric ozone acts as an effective sunscreen.

Most ozone which exists at ground level is produced by another process, also driven by sunlight, in which oxygen molecules react with the products of reactions of nitrogen oxides and hydrocarbons to form ozone. Ground level ozone can reach concentrations which are harmful to humans, vegetation and animals. Too high a concentration of ozone at ground level, then, is undesirable, just as too low a concentration in the upper atmosphere is undesirable.

It is now known that stratospheric ozone may be destroyed by chemical reactions involving a variety of atoms and molecules, which act as catalysts. The principal culprit is thought to be the chlorine atom, which can be released by the action of the sun's ultraviolet rays on molecules which contain chlorine. There are some naturally-occurring chlorine-containing molecules which make their way from the surface of the earth up to the stratosphere, but the major contributors to the current level of ozone destruction are believed to be manmade molecules such as the chlorofluorocarbons (CFC's), which do not occur naturally. Historic levels of ozone in the stratosphere reflect the balance between the natural production and depletion processes. The issue, then, is the enhanced depletion caused by the introduction of the manmade materials.

CFC's were designed to be inert for industrial applications, such as refrigerator coolants. Their inertness, however, allows them to survive intact in the lower atmosphere for a long period of time, which is sufficient for them to diffuse slowly into the upper atmosphere (stratosphere), where they can do their damage. CFC's persist for 70 to 100 years in the atmosphere, and it takes about five years for CFC's released at ground level to reach the stratosphere. For comparison, less stable chemicals, including many other manmade chemicals, have atmospheric lifetimes of minutes to a few years, so that they are destroyed by chemical reactions or removed by physical processes in the lower atmosphere before they can reach the stratosphere. In the stratosphere, the sun decomposes CFC's to release chlorine atoms to participate in a complex chain of reactions which

ultimately destroys ozone. Each chlorine atom is capable of destroying about 100,000 ozone molecules. Other types of manmade chemicals which have been designed to be very stable, and which are used in such a way that they evaporate to the atmosphere, are also effective in reaching the stratosphere to release chlorine atoms. The largest current impact, however, is thought to be from the CFC's.

The decrease in the overall, average concentration of stratospheric ozone which is attributable to CFC's (and other carriers of chlorine atoms) is difficult to estimate. Seasonal decreases of up to 50% have been observed in the "hole" over the Antarctic, and the annual average concentration above Toronto has decreased by about 3 to 4% since 1975. Globally, confirmed observations have shown a 2 to 3% decrease in stratospheric ozone above the Northern Hemisphere (30°N to 64°N) since 1970. It is estimated that a decrease of one percent in the concentration of stratospheric ozone, and its associated increase in the intensity of UV-B at ground level, would result in a 4 to 6 percent increase in non-malignant skin cancer in humans and a one percent decrease in the productivity of some (sensitive) plants, such as soybean. Other biological and climatological effects have been suggested, some of which are related to global warming (see below).

Chemicals which destroy ozone in the stratosphere do not destroy ozone in the lower atmosphere (troposphere), because they require the intense ultraviolet radiation in the stratosphere to decompose and release their chlorine.

The principal remaining uses of CFC's are as coolant fluids in refrigerators and air conditioners, as blowing agents in plastic foam manufacture, in specialized degreasing operations (especially in the electronics industry) and in a few specialized aerosol propellant applications. They have not been used in large-scale aerosol propellant applications such as hairspray and deodorants in Canada since 1980 (when these applications were banned under the Environmental Contaminants Act). Substitutes have been or are being developed for all of these applications. In particular, the substitutes such as hydrochlorofluorocarbons (HCFC's) and hydrofluorocarbons (HFC's) are removed by oxidation more rapidly than CFC's in the lower atmosphere, reducing the amount which can diffuse to the stratosphere. These chemicals themselves, however, are predicted to have a significant impact eventually (by 2025).

Other carriers of chlorine atoms to the stratosphere, such as halons (bromine-containing chemicals similar to CFC's, which are used in fire extinguishers), carbon tetrachloride (once widely used as a cleaning solvent - "carbon tet" - but now used mainly in the manufacture of CFC's) and methyl chloroform (a widely-used cleaning solvent) have somewhat shorter chemical lifetimes in the lower atmosphere than CFC's, but may contribute appreciably to future ozone depletion unless their production is also curtailed. For example, it is estimated that halons may contribute about 10% of the current ozone depletion.

Global production of CFC's declined by about 25% between 1974 (shortly after the ozone depletion problem was first predicted) and 1982, reflecting restriction of their uses as propellants in aerosol spray cans in North America, but non-aerosol uses worldwide have increased substantially since then. Current world production of CFC's is about equal to production in 1975 (just under one million tonnes per year) and is rising.

The mitigation strategy is simple in principle - prevent release of CFC's to the atmosphere. The most effective way of achieving this is to stop production. In addition, any action to slow the rate of release of CFC's from existing equipment and conserve the existing stock (by recycling in-use material) will lessen the impact on the stratosphere by extending the time between manufacture and reaching the stratosphere.

Under the auspices of the United Nations Environment Program (UNEP), international protocols have been developed to control the production of CFC's. The Vienna Convention for the Protection of the Ozone Layer was signed by 22 countries in 1985. The Montréal Protocol was added to the Vienna Convention in 1987. This agreement commits countries which ratify it to reducing the use of CFC's by 20% by 1994 and by a further 30% by 1999. A meeting of the signatories to the Montréal Protocol and 50 additional nations in 1989 agreed to a phase-out of production and use of CFC's by 2000. By the end of 1989, about 50 nations had ratified the Protocol. A recent (1990) review of new scientific data has indicated that the destruction of ozone in the stratosphere which is attributable to manmade chlorine-containing chemicals is worse than was thought in 1987. The review meeting participants have called for a virtual elimination of production and use of CFC's and other volatile halocarbons (any materials containing carbon in combination with chlorine, fluorine or bromine) by 2000. Without such conclusive action, current atmospheric models predict that, in the worst case within the terms of the Montréal Protocol, global reduction of stratospheric ozone could reach 15%, with attendant increase in UV-B at ground level

of 40%, by 2050. In the most optimistic case (Montréal Protocol plus additional restrictions), the models predict that ozone recovery would begin by the middle of the next century.

CFC's are also significant contributors to the group of chemicals known as the greenhouse gases, which are described in the next section. Although the CFC's are present in only trace quantities in the atmosphere (about one-half of a part-per-billion), they have a very high inherent capacity to absorb heat - each molecule can absorb about 20,000 times as much infrared radiation (heat) as a molecule of carbon dioxide. This is an important example of the inter-connectedness of the transboundary issues.

Global Warming

Trace amounts of certain gases in the atmosphere help to trap part of the energy of the sun's radiation which is transmitted through the atmosphere to the earth's surface and re-emitted to the atmosphere as infrared radiation (heat). The natural (that is, pre-industrial) state of the atmosphere was such that gases such as carbon dioxide and methane in the atmosphere, which comprise less than one percent of the composition, allowed it to retain enough heat to maintain the surface of the earth at an average temperature about 30°C warmer than it would be without these gases. This phenomenon has been called the greenhouse effect, and, clearly, without it, the surface of the earth would be continually frozen. Human economic development and the increase in the world's human population have led to an increase of concentration in the atmosphere of gases which enhance the greenhouse effect. The principal contributor to the enhanced greenhouse effect according to current scientific thinking is carbon dioxide, primarily from the burning of fossil fuels.

The concentration of carbon dioxide in the atmosphere has been measured over a long period of time, and other evidence exists to indicate how the concentrations of this and other atmospheric gases have changed over millions of years. There is detailed evidence to show a statistical relationship between atmospheric temperature and the concentration of greenhouse gases over the past 160,000 years. Based on this evidence, we know that the concentration of carbon dioxide, for example, has increased about 25% in the past century. Any accompanying increase in global temperature has been more difficult to detect, but there is consensus among scientists that the average temperature of the lower atmosphere has increased by about 0.5 °C during the same period.

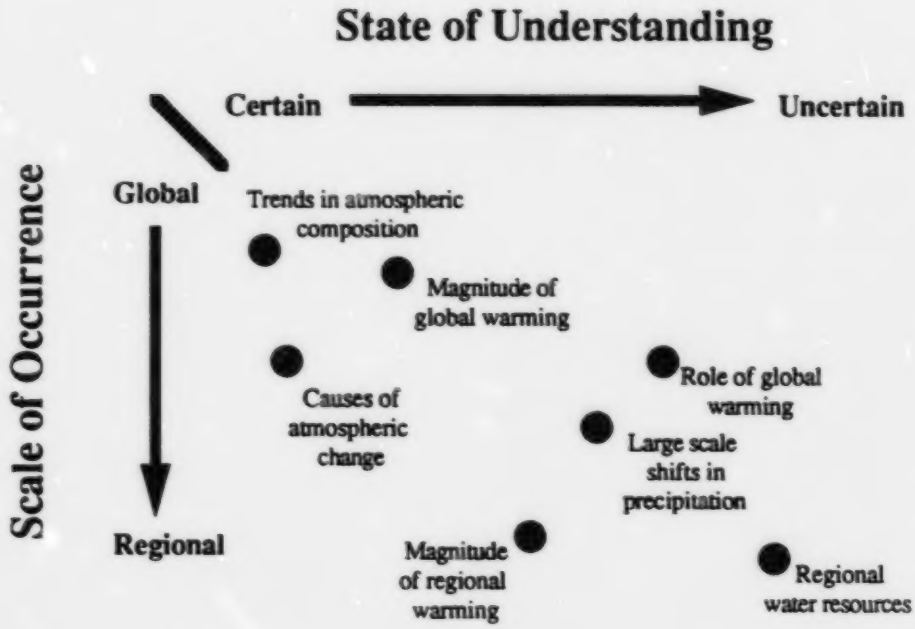
There is some uncertainty about how much the average temperature of the earth's surface will increase in response to the increased temperature of the atmosphere caused by the presence of the enhanced greenhouse gases. Mathematical models predict that at the current rate of increase of greenhouse gases, their concentration will have doubled relative to pre-industrial levels by about the year 2025, and the corresponding range of temperature increase could be between 1.3 and 4.5 °C. Temperature increases in the mid- to high-latitudes of the Northern Hemisphere might be as much as 5 to 9 °C. Surface temperature increases of this magnitude would lead to significant climate alteration and the melting of polar ice to the extent that sea level would rise by 20 to 140 cm (0.2 to 1.4 m) by the middle of the next century.

Figure 1 (taken from an Environment Canada publication) shows the qualitative relationship between the degree of uncertainty of predictions of atmospheric and climate change and the geographic scale of effects. The predictions of overall change on a global scale are much more certain than details on a regional scale. That is, the details of potential local impacts are not known at present.

It should be recognized that the predicted climatic changes are in the range of conditions which have existed at various times in the history of the earth. The importance of the enhanced greenhouse effect and global warming for us at this time is the rate at which these changes are predicted to occur. Although they may be within the "natural" range, human society may not be able to adapt to the impacts quickly enough to avoid serious social disruption and costly mitigating measures.

Carbon dioxide (chemical formula: CO_2) is not the only contributor to the enhancement of greenhouse gases in the atmosphere. Table 1 shows the other known main contributors and their relative roles. The important parameters are the concentration of the gas, the inherent heat absorbing capacity of the molecules and the rate of increase of the concentration of the gas in the atmosphere. When all of these factors are taken into account, the current relative contributions of the main greenhouse gases are CO_2 (55%), CFC's (24%), methane (15%), nitrous oxide (6%) and others (trace). Projections of present trends of these gases leads to the estimate for the year 2025 of their importance in the order: CO_2 (63%), methane (17%), CFC's (7%), nitrous oxide (5%) and others (8%, mainly HCFC's).

Figure 1. Uncertainty in Climate Change Prediction



Source: CO2/Climate Report: 90-01

Table 1. Characteristics of Greenhouse Gases

Greenhouse Gas	Concentration: Present (ppb)	Concentration: Trend (%/y)	Concentration: Projected 2025 (ppb)	Absorption Effectiveness Relative to CO_2*	Residence Time (years)	Contribution to Greenhouse Warming in the 1980's (%)	Manmade Sources
Carbon dioxide (CO_2)	353,000	0.5	450,000	1 (1)	50-200?	55	fossil fuels; deforestation; respiration
Methane (CH_4)	1,720	0.9	234,000	25 (70)	7-10	15	livestock; anaerobic decay; fuel losses
Nitrous oxide (N_2O)	310	0.25	375	250 (160)	150	6	microbial action on fertilizers; fossil fuels & biomass burning
Chlorofluorocarbons:							
CFC-11 (CCl_3F)	0.3	4	1.1	17,500 (4,700)	65	24	refrigerants; degreasers; foaming agents
CFC-12 (CCl_2F_2)	0.5	4	1.8	20,000 (6,200)	130		
Tropospheric ozone (O_3)	10-300	~1	+10%	2,000 (1,800)	0.2	?	sunlight acting on NO_x/VOC's

Note: * Infrared absorbtion on a molecule-for-molecule basis.
Number in parentheses is effectiveness based on weight.

Source: CO_2 / Climate Report: 90-01; IPCC, 1990 and various other sources.

Methane (chemical formula: CH_4) occurs naturally, but its concentration in the atmosphere has also grown in relation to human activities. Methane is produced by a variety of processes, mainly related to the degradation of vegetable matter - by burning, digestion (food) or rotting. It is believed that the global cattle population and rice paddies - both related to human activity - comprise about 50% of current emissions of methane.

About 20% of global methane emissions arise from burning wood and other vegetation. Lesser amounts of methane are released from coal mining and natural gas processing and distribution. Natural sources such as swamps, marshes and other wetlands are believed to contribute most of the remaining emissions (15 to 40%).

Nitrous oxide (chemical formula: N_2O) is produced naturally and from man's activities. Current estimates indicate that about 33% of global emissions of N_2O are manmade - primarily from the action of soil and aquatic bacteria on chemical fertilizers containing nitrogen, and from burning biomass or fossil fuels (where it is a component of the total nitrogen oxides emission, NO_x).

The issue of global warming for B.C., then, might be defined as the need to reduce the uncertainty of knowledge about potential regional effects of climate change associated with global warming. At the present stage of uncertainty about details of future scenarios, knowledge about B.C.'s ability to reduce emissions of the most important greenhouse gases and a flexible, adaptive approach to planning are important.

Long Range Transport of Air Pollutants

Stratospheric ozone depletion and global warming are both examples of processes which involve atmospheric transport of gases great distances from their points of emission. Long range transport of air pollutants (LRTAP or LRT) in a more restricted sense describes similar processes in which air pollutants travel distances of a regional or continental scale to exert their effects. Two prominent examples of LRTAP are acidic deposition (acid rain) and ground level ozone. Both of these examples are important to British Columbia.

LRTAP issues in B.C. have to do with transport of oxidants (ozone and related contaminants) and other air pollution up the Fraser Valley from the urbanized areas in the Fraser delta and with

transport of pollutants from industrialized and urbanized areas of the adjacent U.S. into southern B.C. (and *vice versa*). Preliminary analysis has indicated that most of the oxidant pollution which appears in GVRD and immediately downwind arises from local emissions, but more detailed analysis may show otherwise, since about one-third of the emissions into the Lower Fraser Valley airshed are emitted in the U.S.

Ground level ozone may reach concentrations which are harmful to humans and vegetation. It has reached such levels in the Lower Fraser Valley (including GVRD) in the past ten to fifteen years. The pattern of elevated ozone concentrations, approaching or exceeding levels at which effects are known to occur, has spread further into the Fraser Valley in recent years. There have been numerous occasions on which the Acceptable Level of the National Ambient Air Quality Objective for ozone has been exceeded in the Fraser Valley (Chilliwack, Abbotsford) when this objective has not been exceeded within GVRD. Ozone precursors emitted from sources in GVRD (nitrogen oxides and volatile organic compounds - NO_x and VOC's - mainly from motor vehicles) are transformed by the action of sunlight into reactive chemical species which convert some of the oxygen in the atmosphere to ozone. This production of ozone occurs as the air mass which has been polluted by the NO_x and VOC emissions drifts downwind. The phenomenon takes place almost exclusively during the summer months, when the intensity of sunlight and the air temperature, which are necessary for the chemical reactions to occur in the atmosphere, are favourable, and the necessary meteorological conditions are also prevalent.

Measurements of acidic deposition (acid rain) in B.C. indicate that elevated levels of sulphur deposition (in the form of sulphate) occur over the Strait of Georgia and around the Burrard Inlet. This may be due to locally-generated sulphur emissions (from pulp and paper plants, fuel oil combustion and oil refineries), or sulphur emissions from refineries and other industrial sources in Washington State may be implicated. There appear to be insufficient data at present to evaluate this situation objectively. Soil and lake sensitivity maps which have been developed for B.C. indicate that the mainland coast (from the Sunshine Coast to Prince Rupert) and certain areas on the west coast of Vancouver Island and in the area of Chilliwack are sensitive to acidic deposition. The Sunshine Coast and the North Shore of Burrard Inlet are the regions receiving appreciable acidic deposition currently. The significance of this situation needs to be evaluated. The issue is whether lakes, fisheries and forests in this area are at risk from the observed levels of deposition.

In each of these cases, the sources of emissions are complex, as are the possible control strategies. Emissions of the responsible pollutants and the receptors of their effects occur across a very large geographic area, crossing municipal and regional boundaries and the provincial / state boundary.

Marine Pollution - Oil and Chemical Spills

Each of the previous examples has involved the atmosphere as the medium of transboundary movement of pollutants, but transboundary pollution issues are not limited to air. Spills of oil and other chemicals in ocean-going transport clearly constitute a transboundary pollution issue. Marine spills on the West Coast may impact both Canada and the U.S., and more than one state may be involved in the U.S. Furthermore, the products being shipped have origins and destinations which cross the national and state boundaries, regardless of where they may be spilled. Attention tends to be focused on oil spills, but other chemicals such as herbicides may be far more toxic and should not be overlooked.

Spills of toxic substances not only impact shore areas on which they impinge and their resident bird, mammal and marine life, they may also alter the chemical balance of marine waters, so that biological and geochemical systems in the open ocean are temporarily disrupted. Some argue that resilient ecosystems recover from these impacts with time, so that individual incidents do not threaten sustainability. This appears to be the case in the short term, but the longer term cumulative effects of oil and chemical spills are not well understood. For example, frequent spills could irreversibly affect populations of larger long-lived species such as seabirds and large crustaceans. The issue of sustainability should focus on the cumulative impacts of all spills off the West Coast.

As in the atmospheric issues summarized above, the persistent components of spilled chemicals like petroleum products in the marine and shore environments also project spill incidents into long-term, sustainability issues. These materials, once released, spend a considerable amount of time in the environment and, therefore, may exert their effects over a large geographic area and impact many different ecosystems. Bioaccumulation of these contaminants may also cause problems. The effects of many spills may overlap in time and space, so that the cumulative effects may be more than the sum of the individual events.

The report of the States / British Columbia Oil Spill Task Force (October 1990) summarizes the

significant spills of petroleum products which have occurred off the West Coast over the past twelve years. At least one significant spill has occurred off the coast from California to Alaska in each of these years, comprising at least 25 different events.

Although the Task Force places highest priority on preventative measures, it also identifies deficiencies in B.C.'s capability to respond to spill incidents to mitigate the effects of released oil. There are a number of issues identified by the Task Force related to developing or procuring emergency response or clean-up technologies.

The preventative aspects of oil and chemical spill risk management are important to long-term sustainability, especially when the cumulative impacts of current and future shipping are considered, but emergency response is also important in the shorter-term. These two aspects - short-term preparedness coupled with long-term planning for prevention - are common to all of the transboundary issues addressed in this paper.

World-wide, releases of oil from coastal well production accidents are minor contributors to marine oil pollution compared with transportation accidents or routine deliberate releases, but the implications for any anticipated off-shore drilling programs should be recognized.

Other Transboundary Issues

Other environmental sustainability issues which are transboundary in nature, or have a transboundary component, could be cited. A few such issues are

- Water quality and quantity
- Cumulative impacts of multiple projects and industries.

These issues are comprised of many local and regional issues which involve B.C. and her neighbouring province, territory and state. Both Western Canada and the Pacific Northwest of the U.S. are rapidly developing economies. Economic growth means that existing developments and the additional urbanization and industrial developments will encroach on one another, and their combined impacts will increase. Planning for and managing these impacts are both important.

Examples of current issues in the area or **water quality and quantity** which are being

addressed are the Columbia River Treaty between Canada (B.C.) and the U.S. and the Peace River Accord between B.C. and Alberta / N.W.T. The Columbia River Treaty has been in place for nearly 30 years and is scheduled to be revisited for 1994. The principal issues have focused mainly on water quantity - flood control and power production - of the projects on the Canadian side. The treaty agreements address the apportionment of downstream benefits and their compensation. Water quality and water quantity and their effects on the salmon fishery have also been important points of discussion during the tenure of the Treaty. Both water quantity and water quality are being addressed in the negotiations of the Peace River Accord. Thus, each of these ongoing actions provides a model and a mechanism for mutually addressing sustainability. For example, effluents from B.C. pulp mills that enter rivers flowing into Alberta have been subject to examination as a result of the hearings on the Alberta-Pacific Forestry Project and could be dealt with under the Peace River Accord.

Another issue of this type resurfaces each time expansion of hydroelectric facilities on the Liard River is proposed. Dams that are planned on the Liard will reduce the amount of sediment transported to the Mackenzie and, eventually, to the Mackenzie Delta. The Delta and its biota are dependent on the seasonal deposition of sediment during the Mackenzie River's annual flood. Reduction of the rate of deposition will affect the growth and stability of the modern (as opposed to Pleistocene) delta and the composition and vigour of its fauna and flora. If the rise in sea level that is forecasted by most models of climate warming actually occurs, the effects on the Delta could be exacerbated.

A different type of transboundary issue was illuminated by the decision early in 1990 by the National Energy Board to require examination of the environmental effects of end uses of energy exports. This directly affects the electrical generation and oil and gas industries in B.C. If the federal government chooses to extend the principle, it could also be applied to exports of B.C. coal.

Cumulative effects of multiple projects and industries present obvious potential difficulties. Some specific transboundary examples which need to be considered in planning for environmental sustainability include

- fisheries
- ocean waste dumping

- municipal / industrial waste effluent discharge
- hazardous waste disposal
- linear developments, such as transmission corridors or pipelines.

The list is not intended to be exhaustive, rather illustrative. Each of these activities in which B.C. or Canada may be involved impacts the environmental "commons" of more than one jurisdiction. A framework for dealing with some of the major issues will also provide experience and institutions to deal with other issues. These related issues are not developed further in this paper.

The following sections develop the local dimensions of the four major issues in more detail and cite examples of actions which are being taken at the local level to influence the outcomes at the global level. Each issue is presented in terms of local contributions to the problem and local contributions to the solution.

3 STRATOSPHERIC OZONE DEPLETION

Local Contributions to the Problem

Many of the important contributors to the buildup of gases which lead to stratospheric ozone depletion are emitted in B.C. CFC's are present in the compressor / cooling coil system of nearly every refrigerator unit. They leak out and evaporate over time, especially as discarded units corrode. In normal service, the refrigerant does not evaporate rapidly. CFC's in air conditioning units (whether in automobiles or building units) normally require "topping up" as the coolant leaks out through gaskets and connectors. B.C.'s contribution to this aspect of CFC emission in Canada is significant because of its relatively large population, but the per capita emission is probably lower than the Canadian average because of the relatively mild climate and consequent lower demand for auto and home air conditioning. CFC use for critical degreasing applications in the electronics industry is probably low in B.C. because of the relatively small size of that industry in the province, so that the related emissions of CFC's are also likely to be low. Halons are used in industrial fire extinguishing systems and are expected to be present in those systems in B.C. Almost all of Canada's usage of carbon tetrachloride (greater than 99%) is in the manufacture of

CFC's, and since CFC's are not manufactured in B.C., the current B.C. emission of this chemical is expected to be essentially zero. Methyl chloroform's primary use as a common metal degreasing agent implies that it is used extensively in B.C., suggesting that its emissions here are also significant on a per capita basis. An emission inventory of each of these materials is about to begin in B.C. as part of the Provincial Government's Greenhouse Gases Project (see the next section).

Local Contributions to the Solution

It is important that we not wait for absolutely conclusive evidence of major ozone layer depletion before deciding to take action, because the long time lag between production and release of ozone destroying chemicals and their reaching the stratosphere delays the observation of effects of current emissions well into the future.

The report of the City of Vancouver's Task Force on Atmospheric Change, *Clouds of Change*, provides many recommendations for mobilizing local action toward alleviating B.C.'s contributions to stratospheric ozone depletion. Examples are given of action taken by a number of other large cities in North America (including Toronto) to speed achievement of phasing out production of CFC's and other important gases. For example, more than 100 North American cities have taken action from banning plastic foam food packaging (if it is produced by using CFC's) to comprehensive bans on the use, sale and manufacture of ozone-depleting chemicals. Some cities require automobile service stations and repair shops to capture and recycle air conditioner fluids. One Vancouver Task Force recommendation is intended to reduce and eventually eliminate Vancouver's emissions of stratospheric ozone-depleting chemicals. The Task Force points out that there are economic alternatives to most applications of these materials at present, so that there is reason to believe that production and use can be effectively stopped among the signatory nations to the Montréal Protocol. Less developed countries may require assistance to be able to afford to convert to the new technologies.

B.C. Ministry of Environment is developing a strategy to control CFC's in-use and has prepared a draft regulation under the Waste Management Act to control ozone depleting chemicals. It is proposed to establish recycling depots to capture CFC's from refrigerators and to establish controls on the amount of CFC's used in automobile air conditioners. The recycling technology exists currently. The major manufacturers of CFC's, such as duPont, have already committed to phasing

out almost all North American production (95%) of the implicated chemicals by 2000. Thus with concerted action at the local level, North America's contribution to the problem will be curtailed in the next decade. It will be a major challenge for Canada, presumably with B.C.'s support, to help expedite this achievement on a global scale.

Since CFC's are also significant contributors as greenhouse gases, attention to their elimination as ozone depleters will also help with that issue.

4 GLOBAL WARMING

Local Contributions to the Problem

British Columbia currently emits the greenhouse gas carbon dioxide (CO_2) approximately in proportion to its population as a fraction of Canada's total CO_2 emission - that is, about 13% of the national total. A recent inventory of CO_2 for B.C. indicates that about 35% of man-made CO_2 emissions in the province come from industrial stationary (point) sources, of which about 80% (or 30% of the total) are from the forest products sector. When CO_2 emissions from pulp and paper, prescribed burning (slash and fire control) and the wood products industries are combined, the forestry-related contribution to the total is about 40%. Motor vehicles and solid waste disposal together contribute about 25% of total CO_2 emissions. Existing inventories do not include natural sources of CO_2, such as forest fires or human respiration.

B.C. also contributes emissions of other important greenhouse gases - methane, CFC's, nitrous oxide and tropospheric ozone. These emissions are in the process of being inventoried for B.C., so that quantitative data are not available, but guesstimates of their relative importance in B.C. can be made. As pointed out in the previous section, B.C. is likely to produce less than its proportionate share of Canada's CFC emissions, because of the relatively mild climate which lessens the need for automotive and home air conditioners. B.C. also has relatively small electronics and foam manufacturing industries, so that the remaining industrial applications of CFC's would contribute little. End use emissions of CFC's from polymer foam materials imported into B.C., such as rigid home insulation panels and foam beverage containers and packaging, however, would be proportionate to population. B.C.'s relative emissions of methane

and nitrous oxide are more difficult to estimate, but one would guess that the relatively large amount of wood burning which occurs in the province, along with rotting wood and slash, would produce significant emissions of both. Coastal estuaries and wetlands and agricultural lands in the Lower Fraser Valley would produce emissions of methane and nitrous oxide from microbial activity on fertilizers and other nutrients. Methane would also be produced by industrial processing of natural gas and coal deposits in the province, and small amounts of methane would be released from system leaks in transport and use of natural gas for heating and vehicle fuel.

Local Contributions to the Solution

B.C. can contribute to the resolution of the global warming issue in several ways. First of all, since the details of the issue, and whether or not it will become a serious problem for B.C., are not well understood, it is important for B.C. to monitor on-going research and policy developments elsewhere. B.C. is well-positioned here, since a member of the UBC faculty, Dr. Gordon McBean, is chairman of the joint scientific panel of the World Meteorological Organization (WMO) and the International Council of Scientific Unions, which is cooperating in the Intergovernmental Panel on Climate Change (IPCC), created under sponsorship of WMO and the United Nations Environment Program. The formation of the IPCC is significant because it will serve as the model for the international community to share scientific information and policy initiatives for other issues of global environmental sustainability. Figure 1 suggests that regional studies of potential impacts of climate change are warranted.

B.C. is already developing a comprehensive management strategy for the greenhouse gases, having struck a set of interministerial committees to oversee the preparation of emission inventories of related groups of these gases and the development of management strategies for each. These committees are addressing the greenhouse gases in the following groups:

- carbon dioxide (inventory already prepared)
- NO_x (including N_2O) / VOC's / ozone
- methane
- halocarbons (CFC's, halons, HCFC's, CCl_4, CH_3CCl_3).

The management strategy which is developed for these gases will need to address the close connections among energy production, modes of transportation and industrial technology which are related to their production and emission to the atmosphere. For example, the cost of significant

changes in the economic structure necessary to achieve a 20% reduction in CO_2 emissions by the end of this century, the international goal to which Canada has agreed in principle, would mean major societal commitments.

5 LONG-RANGE TRANSPORT OF AIR POLLUTANTS

Local Contributions to the Problem

Measurements by B.C. Ministry of Environment at its 14 LRTAP monitoring sites show that acidic deposition is appreciable at a number of sites along the coast, in the Strait of Georgia and on the North Shore. Sites such as Port Hardy, Squamish and Kitimat among those experiencing the higher deposition levels are impacted by local point sources. The relatively high acidity of the deposition at Vancouver Airport, East Richmond, Mount Seymour and Seymour Dam sites indicates that local sources are also probably important. The highest levels of acidic deposition have been recorded at Victoria, where both local sources (fuel oil burning) and impacts from long-range transported acidity from sources in Washington State are probably important. The true sources of the observed acidity have not been identified conclusively, but the pattern shows that both local and long-range transported material contribute.

The measured levels of acidity at the MOE sites range up to 20 kilograms per hectare per year (abbreviated kg/ha/y) of sulphate in wet deposition in the Seymour Watershed, which is at the level of the Eastern Canadian standard for moderately sensitive receptors. For comparison, the target loading limit for acidic deposition in western Canada which has been proposed by the Western and Northern Canada LRTAP Technical Committee is equivalent to a range of approximately 6 to 15 kg(sulphate)/ha/y for sensitive areas. The applicability of this level to coastal B.C. is uncertain because of the relatively large volume of precipitation it receives compared with the other areas of western Canada for which the limit was developed. Thus, B.C. MOE is evaluating the appropriate target loading limit of acidity for coastal B.C. The potential effects on B.C. forestry, fisheries, lakes and soils are still to be assessed.

There is little doubt that most (but not necessarily all) of the ground level ozone which is observed in the Lower Fraser Valley is produced from local emissions. Detailed analysis may show that

emissions of precursor gases from sources in Washington State contribute to the background concentrations of these materials, which are augmented by local emissions and converted to ozone downwind (primarily east) of the Fraser delta.

The Acid Deposition Research Program in Alberta has implicated long-range transport of ozone from B.C. as a significant contributor to measured ozone levels at sites in the foothills east of the Rockies. The scientists who collected the data postulate that ozone-contaminated air flows through mountain passes into Alberta. This aspect of the issue has not been addressed further.

Local Contributions to the Solution

With regard to acidic deposition, the first order of business is to determine how significant are the observed levels of acidic deposition. No direct effects of acidic deposition have been observed in B.C. Research is currently underway involving GVRD, B.C. MOE and Environment Canada to monitor acidic deposition and to determine its sources. B.C. MOE has expressed commitment to controlling emissions of acidic species by the permitting system where necessary. The broader

issue of transboundary cooperation with Washington State to assess and control sources of acidic deposition precursors is also being addressed. There is a Memorandum of Understanding between B.C. and Washington State to cooperate in addressing such transboundary environmental issues. B.C. cooperates with the Western Conifers Research Cooperative (part of the Integrated Forest Studies Program sponsored by U.S. EPA and other agencies), which is evaluating impacts of air pollution (multiple pollutants) and climatological factors on tree growth in a number of areas of the Western U.S., including the Olympic Peninsula and Puget Sound.

Emissions of VOC's have been targeted to reduce concentrations of ozone precursors in the Lower Fraser Valley, and a pilot project is now underway by the petroleum producers in the Lower Mainland to capture VOC emissions in their refining and gasoline marketing systems. Responses to a request for proposals have just been received by the B.C. Government to initiate a vehicle emissions inspection and maintenance program, initially in the Lower Mainland. This program is anticipated to reduce ozone production by reducing both NO_x and VOC emissions from automobiles. Researchers at UBC have estimated that the current cost of crop damage in the Fraser Valley due to ozone is several million dollars per year.

6 MARINE POLLUTION - OIL and CHEMICAL SPILLS

Local Contributions to the Problem

The States / B.C. Task Force report shows that there are over 2500 barge and tanker loadings and unloadings of refined petroleum products in Vancouver Harbour each year. Much of the outbound material is destined for B.C. coastal sites for unloading, since Vancouver is the only source of supply for Vancouver Island and for many mainland coastal communities. This traffic uses the Strait of Georgia, Johnstone Strait and Queen Charlotte Strait, as well as Juan de Fuca Strait. Crude oil from Alberta arrives at Vancouver by pipeline for refining or trans-shipment. 1.24 million cubic metres (14 tanker trips) of crude oil were shipped out of Vancouver by tanker in 1988 *via* the Juan de Fuca Strait.

For comparison, over 330 tanker trips (25 million cubic metres) per year of crude oil use the Juan de Fuca Strait to bring (mainly Alaskan) crude oil to refineries in Washington State. Each tanker trip represents a risk of spill, so that the B.C. contribution to the total risk, especially in the Strait of Georgia and Johnstone Strait, is significant. Shipments of other chemicals that may be toxic or have other environmental effects should also be considered. The report of the recent (1987) Vancouver area Transportation of Dangerous Goods Study shows that about 1.5 million tonnes of goods classified under the federal Transport of Dangerous Goods Regulation (excluding about 2 million tonnes of petroleum products and crude oil) were moved by marine transport in the Vancouver area in 1986. These commodities included, for example, caustic soda (550,000 tonnes), methanol (275,000 tonnes), ethylene dichloride (160,000 tonnes) and styrene (150,000 tonnes).

Local Contributions to the Solution

The States / B.C. Oil Spill Task Force operates under a Memorandum of Co-Operation between the Province and the four West Coast states. The Task Force has presented a large number (46) of joint recommendations and an additional number of individual member recommendations (including many from B.C.). The joint recommendations are ranked in priority respecting highest potential for spill risk reduction, in keeping with the risk analysis and risk management principles which guided the Task Force's work. The two highest priority actions are petroleum conservation

and alternative transportation means. The former would reduce the volume of crude and refined petroleum products to be transported, and the latter would re-route the products, primarily by new pipelines, directly to the coast, so that they would not be transported by high risk means (tankers) through Johnstone, Georgia and Juan de Fuca Straits. Many of these recommendations echo those made by David Anderson in his *Report to the Premier on Oil Transportation and Oil Spills* (November 1989), as Special Advisor to the B.C. Government.

In the short term, improvement of local capability to respond to major spills should they occur in or off B.C. waters is an important component of risk management for oil spills. There is marine traffic in chemical commodities other than oil, and preparedness for oil spills would also improve preparedness for other chemical spill emergencies. Attempts to improve spill response capability should be tempered by the realization that it may not be possible to contain very large spills such as those which may arise from supertanker accidents or well blowouts, whatever equipment is on hand, and however close to the scene the equipment is stationed. Furthermore, cleanup of contaminated beaches should be carefully planned and monitored. The point in the cleanup process after which further work can become counter-productive is the subject of active debate.

7 CONCLUSION

This brief summary of some of the transboundary issues facing British Columbians has emphasized the complexity of all such issues - both environmental and socio-economic. The conclusion to this paper attempts to draw together the common threads of these issues and to emphasize some of the successful responses to them that are already underway. The latter may serve as examples of how we in B.C. might actively develop cooperative approaches to addressing the most pressing of the outstanding concerns.

It is not intended to imply that the existence of agreements or task forces or committees is the end of the story in addressing environmentally sustainable economic development. The examples summarized here show the way toward mutual action to prepare for or to prevent the effects of development impacts - they do not necessarily provide all of the solutions which will be necessary. Activities such as the coordinated international effort to control emissions of ozone-depleting chemicals, under the auspices of the United Nations Environment Program, have created the

networks and diplomatic tools for defining the framework and strategies for achieving concerted action. This process has not been entirely successful - for example, it is not clear how to manage technology transfer to the developing world to offset the economic effects of stopping production of CFC's - but international communications and understanding about this issue have been greatly improved by the process to-date.

There is every reason to believe that the process which has been put in motion to control ozone-depleting chemicals will contribute greatly to expediting advances in research and implementing actions to control greenhouse gases and global warming.

The cooperative example of B.C.'s acting with the four U.S. states in the Oil Spill Task Force, presuming that its major recommendations are implemented, shows the power of mutual action to address impacts on shared environmental resources. The experience of building this model and designing this process can be applied to dealing with other issues in the future, if the will to do so persists.

The principal conclusion of this paper is that the process to address impacts on the regional or global environmental "commons," as illustrated by the few examples given here, is important to the development of appropriate strategies for environmentally sustainable economic development for B.C. This process will be needed increasingly for issues in which B.C. is or will be involved. With mechanisms in place to recognize and define issues and examples of model approaches, there is a good chance that successful strategies can be conceived.

This paper has not touched on mechanisms for setting priorities among many competing transboundary issues. That is a difficult problem which has yet to be addressed. Indeed, the extent to which the setting of priorities is desirable or necessary has not been fully explored. However, it is less of a challenge than the problem of recognizing important issues at a sufficiently early stage, and that challenge is being met by the establishment of new consultative procedures such as those of the Round Table.

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